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Synthesis, Electrochemical Characterization and Determination of Photocatalytic Activity of Zn Doped Iron Oxide / Graphene Oxide / Chitosan Nanocomposite

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Abstract

Nanocomposite of Zn doped Iron oxide/Graphene Oxide/Chitosan were prepared by simple solution mixing and evaporation using ultrsonication. Formation of composite in nano dimensions was proved by XRD, TEM and AFM studies. Electrochemical characterization of the nanocomposite showed that the composite had good electrochemical stability. Nyquist plot showed well defined semicircle indicating its good capacitance behavior. Impedance studies through Bode phase angle plot showed phase angle of nearly 90° indicating the nanocomposite is a very good candidate for supercapacitor applications. The synthesized nanocomposite showed photocatalytic activity in sunlight against methylene blue dye with an efficient removal of 97.2% in 60 minutes.

Keywords: *AFM; Chitosan; Grapheneoxide; Nanocomposite; Photocatalytic activity; TEM.*

1. INTRODUCTION

Grapheneoxide (GO) and functionalised grapheneoxide have attracted the attention of scientific community as they have a variety of novel applications due to their excellent chemical and physical properties, including low density, exceptional mechanical properties, large surface area, inherent impermeability, mechanical strength, and excellent electrical conductivity. GO can be dispersed throughout a selected polymer matrix to make GO-based composites with excellent mechanical and thermal properties. To harness the benefits of photocatalytic activity of zinc, magnetic property of iron oxide (Fe_3O_4), biodegradability of natural polymer chitosan(CHI) and electrical conductivity of GO a novel nanocomposite was synthesized by simple solution mixing and evaporation method. Special emphasis was made to evaluate the electrochemical nature of the synthesized nanocomposite and its efficiency to degrade Methylene blue dye.

2. EXPERIMENTAL METHODS

Each of the components were synthesized separately (GO from graphite flakes, CHI-commercial sample, Zn doped Iron oxide using $ZnCl_2$, $FeCl_3$ and $FeSO_4$ with PEG as solvent) and then mixed in solution phase at room temperature. The solutions were degassed for 30 min in a desiccator. The resultant Zn doped Fe_3O_4-GO-CHI nanocomposites were separated by ultracentrifuge and dried at 70° C for 8 hours to remove the solvents. The dried samples were soaked in 2 wt. % aqueous sodium hydroxide for 1 hour to remove the acid and washed with water to neutrality and then dried at 70 °C for 6 hours. The homogenized, dried samples were used for characterization. Photocatalytic degradation property of the synthesized nanocomposites was also investigated using methylene blue(MB) dye as probe molecule on exposure to sunlight.

3. RESULTS & DISCUSSION

3.1 XRD and Microscopic studies

X-ray diffractogram showed a shift in the GO-CHI peak from $2\theta=20^0$ to $2\theta=19.5^0$ and also a significant enhancement in the broadness of the peak indicating the strong interaction between the components of the nanocomposite as well as the formation of the composites in nano domain (Ding *et al.* 2015). The particle size calculated was found to be 23.96nm. TEM image of nanocomposite reveals the presence of exfoliated GO in the matrix of chitosan with the Zn doped Iron oxide incorporated into it with the particle size of 20nm. AFM of the nanocomposite shows the presence of a larger specific surface area and more active sites (Christelle Pau Ping Wong *et al.* 2015).

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3.2 Electrochemical studies

CV taken using three electrode system by coating the nanocomposite onto glassy carbon electrode surface and scanning in the range from 50mV/sec to 500mV/sec (Fig.1A) shows that with increasing scan rate the peak current also increased thus indicating good adherence and electrochemical stability of the composite. Interestingly, the CV taken at higher scan rate viz.,500mV/s exhibits current of 2.724×10^{-5}A and well defined redox peaks showing the fast electro activity of the composite material. EIS studies carried out through Nyquist plot shows the formation of well defined semicircle (Sezai Sarac *et al.* 2008).

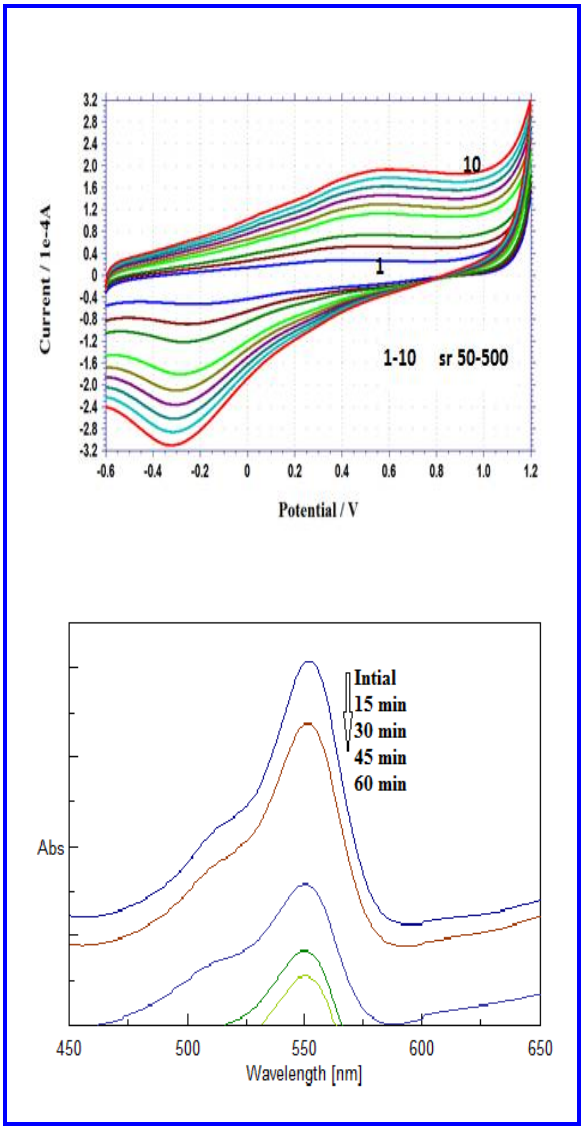

Fig. 1: A. CV of the nanocomposite with varying scan rate
B. Degradation of MB dye with time

3.3 Photocatalytic activity

Photocatalytic degradation property of the synthesized nanocomposites was also investigated using methylene blue dye as probe molecule on exposure to sunlight. It showed 93.2% degradation efficiency after exposure of about 60 minutes as shown in Fig.1.B.

4. CONCLUSION

Novel Zinc doped Ironoxide / GO/ CHI nanocomposite was sythesised by simple solution mixing- evaporation method from cheap and commercially available precursors. The XRD, TEM and AFM revealed the formation of nano sized composites with 20nm dimensions. Electrochemical characterization of the nanocomposite showed good electrochemical stability as well as high capacitance behavior with the Bode phase angle of 87. The nanocomposite exhibited enhanced photocatalytic activity in a short interval of time and hence can be efficiently used as photocatalyst in the process of removal of organic dyes for environmental cleaning and water purification.

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